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ABSTRACT

This Cooperative Extension Service publication from Mississippi State University is a training guide for commercial pesticide applicators. Focusing on forest pest control, this publication examines plant and animal pest control practices for southern tree species. Contents include: (1) identification of insects, diseases, and weed tree species; (2) basic properties of insecticides, fungicides, and herbicides; (3) concentration, formulation, and mixing of pesticides; (4) application methods such as sprays, dusts, granular applications and mechanical-chemical applications; (5) environmental safety considerations such as drift and volatilization, disposal of pesticides and their containers and the effects of pesticides in soil and water; and (6) some recommended forest pest control practices for Mississippi. A reference list is also included. (MR)

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training for certification

Cooperative Extension Service
Mississippi State University

Forest Pest Control

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SE 024 754

FOREST PEST CONTROL

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February 3, 1976

This training manual is intended to provide you with information needed to meet the standards of the Environmental Protection Agency for commercial pesticide applicator certification. Users of restricted use pesticides must pass written examinations to be certified. This manual will help you prepare to take the examination for the category, Forest Pest Control, given by the Mississippi Department of Agriculture and Commerce, Division of Plant Industry. It is not intended that this manual provide you with all the information you need for an effective Forest Pest Control Program.

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FOREST PEST CONTROL

A. INTRODUCTION TO FOREST PEST CONTROL

Foresters are generally concerned with the management of groups of trees that are relatively uniform in species composition, size, and density called stands. The long range objective of most forest management programs is to increase quantity and quality of the timber crop. Intensive forest management programs and the associated technology of forestry production has necessitated the conversion of mixed-species stands to stands of a single species. This trend toward stand monoculture and the economics of forest production have brought about the need for forest pest control.

The control of forest pests is somewhat limited as compared to pests on agricultural crops because, in general, forest stands have a relatively low value per unit of area. Consequently, expenditures on them for pest control must be relatively small. Intensive control methods for insect and disease pests are only economically possible on small areas where the crop or the individual tree has a high value such as seed orchards, forest nurseries, and shade trees. Control of woody plant pests is the major problem affecting nearly every forest stand and right-of-way. Woody plant pests, or weeds, may lower stand yields, increase the costs of reforestation, decrease the rate of growth of individual trees, harbor insect and disease organisms, reduce product quality, compete for available water and nutrients, and reduce management and harvesting efficiency.

In much of the southern United States, pines are the most important commercial species. Approximately 80 percent of the land area is best suited for pine production because of existing site conditions resulting from depleted topsoil layers, deteriorated soil quality, and the stages of plant succession. Control of unwanted woody plants is the primary pest problem in pine management because without control, natural plant succession is toward a climax type of oak-hickory.

B. PRINCIPLES OF FOREST PEST CONTROL

Pest Control refers to any method that can bring about the reduction or prevention of damage caused by a pest or the elimination of the pest organism. This objective can be accomplished naturally or by applying some direct effort; thus pest control methods are referred to as either natural control or applied control.

Natural Control results when the operation of the naturally occurring environmental factors are such that the pest is adversely affected or reduced in numbers so that the economic damage does not occur. Natural pest controls are inoperative in most forest management situations because intensive management practices require immediate and effective result.

Applied Control methods may be classed as (1) indirect control by silvicultural and management techniques, (2) direct physical or mechanical methods which destroys the pest or his habitat, (3) biological control from predators or parasites, (4) regulatory control methods involved regulatory agencies and laws, and (5) direct chemical methods. Of these applied methods, the first, second, and fifth classifications are the most widely used in forest pest control. While silvicultural and mechanical control methods are widely employed in forestry and must be combined with direct chemical methods for effective forest pest control programs, only the direct chemical methods will be considered in ensuing discussions.

C. FOREST PEST IDENTIFICATION

The protection of forests from pests (insects, diseases, and undesirable woody plants) and a reduction in timber losses cannot be accomplished without adequate knowledge of pest identification and biology. Trees in a vigorous condition are better able to withstand harassment by insects, infestation by disease, and competition from other woody plants than devitalized trees.

1. Insects: The main classification category used in insect identification is the type of tree damage. These types of tree damage are as follows:

   a. Defoliation. All or part of the foliage is eaten by insects that have mouthparts adapted for chewing. Species of insect defoliators belong to five orders. These are the moths and butterflies(Lepidoptera), the sawflies and leaf cutting ants (Hymenoptera), the leaf beetles and chafers (Coleoptera), the grasshoppers and walking sticks (Orthoptera), and fly leaf miners (Diptera). Only the larvae (caterpillars) of the Lepidoptera, Hymenoptera, and maggots of Diptera are leaf feeders, whereas both the immature and adult stages of Coleoptera and Orthoptera can cause feeding damage.

      The bagworm is a pest that often attracts attention because of its unusual habits and appearance. It is generally recognized as a defoliator of conifers; particularly juniper, cedars and arborvitae but is also found on many hardwood trees.

      Damage is caused by the larvae which are inside the bags. The larvae eat the needles or leaves, and a heavy infestation can completely strip a plant of its foliage. Complete defoliation usually results in the death of the tree. Bagworms are easily identified by the spindle-shaped bags of silk, covered with bits of needles or leaves, that they construct around themselves.

      The winter is passed in the egg stage. About 500 pale, whitish eggs are laid inside the protection of the bag by the female at the end of the summer. She then drops to the ground and dies. Larvae hatch in the spring after the trees have their full foliage.

The adult male is a black, hairy moth. It measures about one inch across the spread wings. The female is whitish, worm-like, and has no wings or antennae. The male moths leave the bags and fly to bags containing females where mating takes place. There is only one generation of the insect each year.

b. Inner-Bark Boring. The nutritious succulent phloem and cambium tissues are destroyed by insects that chew their way through the inner bark. In damaged trees, the open or frass-packed tunnels are very evident. Inner-bark boring damage is caused chiefly by beetles. Bark beetles girdle the stem with galleries, blocking the downward translocation of foods and cause the roots to die. The most commonly encountered beetles are from the order Coleoptera and family Scolytidae.

The southern pine beetle (Dendroctonus frontalis) is the most destructive of the eastern species of pine bark beetles. It is a small reddish-brown to black beetle, about 1/8 of an inch in length and the rear end of the body is rounded like that of the black turpentine beetle. Small "pitch tubes" are sometimes present from soil line to about 2/3 the way up the trunk.

Adult beetles bore directly through the bark, mate, and the females begin to excavate S-shaped egg galleries in the inner bark. Eggs are deposited in niches on either side of these galleries and hatch into small legless grubs within four to nine days. The grubs mine f or a short distance before boring into the outer bark where they pupate. There are from three to seven generations per year depending on locality and weather. Soon after a tree is attacked, all the needles turn yellow and then brown. Drought seems to be associated with initiation of major outbreaks of this insect.

In addition to direct damage caused by the southern pine beetle, they introduce stain-causing fungi which invade the trees and hasten their death by clogging the water-conducting tissues. An example of one of these fungi is the blue-stain fungi.

Ips engraver beetles are 1/8 to 1/4 of an inch in length and are yellowish, dark reddish-brown to black in color. They are easily recognized by their "scooped out" posteriors which are surrounded by varying numbers of toothlike projections. In hot weather, it takes only 18-25 days to complete one generation. Populations of these beetles increase very rapidly during favorable conditions.

The fully grown larvae and pupae are yellowish-white and vary from 1/3 to 1/4 inch in length. Gallery patterns are more or less Y or H shaped. The eggs are very small and white in color. Eggs are laid singly in small egg niches cut along the main tunnels. Upon hatching, the larvae feed in generally indistinct lines and larval feeding tunnels are usually filled with boring dust and frass.

Attacked trees are quickly girdled by the adults as they construct their egg galleries in the inner bark. Death is usually hastened by the introduction of blue-stain fungi which blocks the flow of sap. Small reddish tubes are frequently the first sign of attack, but they are usually absent in trees suffering from drought.

the black turpentine beetle is the largest of the major southern bark beetles. It is 1/4 of an inch or more in length and the rear end of this beetle is rounded. The color is from reddish-brown to black. Large "pitchtubes" are often present up to eight feet on the trunk. It attacks fresh stumps and living trees by boring through the bark and constructing galleries on the face of the sapwood where eggs are laid. Fifty to 200 eggs are laid in a group. They hatch into white larvae which feed on the inner bark. The beetle may girdle trees when several broods occur at approximately the same height, killing the trees. From 70 to 90 percent of the trees attacked by the beetle die. The entire life cycle takes from 2 1/2 to 4 months, depending on temperature. In the South, there are usually two generations and part of a third each year.

c. Wood Boring. Holes of various sizes and shapes are bored in the wood of the main tree bole, the larger branches, and in dried wood by many species of insects. Most insects found boring or living in wood are beetle larvae. The more important wood borers are the powder post beetles, the flat-and round-headed borers, the termites, and the carpenter ants.

d. Sapsucking. Spotting, discolorations, malformations and/or general devitalization of the foliage, twigs, or other plant parts are caused by insects and mites that have mouthparts adapted for piercing and extracting plant sap. Solid parts of the plants are never consumed. The order homoptera includes most of the sap-sucking insects such as aphids or plant lice and scales.

e. Oviposition. A type of damage consisting of slit-like punctures in twigs. These punctures are made by the female insects when they lay their eggs.

f. Bud, Twig, and Seedling Damage. Weevils and caterpillars damage growing tips whereas insect borers eat the bark and girdle the twigs.

Pine tip moth caterpillars first bore into and destroy the buds, then extend their tunnels into the adjacent parts of the twig for a distance of only a few inches.

The importance of the pine tip moths on pine plantations and nurseries varies widely with tree species, host vigor, and environmental factors. Heavily infested trees may be severely stunted or deformed but mortality is rare. Generally, the tree grows out of the susceptible stage within a few years. In seed orchards, however, the tip moth is receiving increasing attention because of its impact

on height, growth and, more importantly, because of its effect on flower and cone production. All species of pines are attacked except white pine and longleaf pine.

The adult moth is mixed grey and shiny copper colored with a wingspan of approximately 1/2 inch. The young larvae are light cream colored and mature larvae are light brown and approximately 3/8 inch long. Pupation occurs on the tree in the damaged terminal.

One of the most injurious debarking weevils is the pales weevil. Only the adults cause tree injury. They eat irregular areas of bark from the twigs and sometimes almost completely debark the seedlings. Recently planted trees are injured most frequently. The weevils are attracted to recently cutover pine lands where the fresh roots provide suitable larval host material.

g. Root Feeding. The most serious problems caused by root feeding insects occur in forest nurseries and in young plantations. Many of these insects consume the fibrous and smaller roots while others bore into the roots, root weevils, root bark beetles and root maggots cause serious losses in both nurseries and plantations.

h. Destruction of Cones and Seed. This type of damage is always done by borers that excavate the seed or chew holes through the cones, nuts, or other types of fruit. The most injurious of these insects are caterpillars, cone beetles, weevils, wasps, and maggots. These insects are of primary concern in seed orchards.

2. Diseases: Diseases may be classified in various ways, the classification depending on the purpose to be served. They may be classified on the basis of cause, symptoms, hosts, or the part of the plant affected. Classification according to the part of the plant affected such as root diseases, is probably the simpliest of the classification systems.

a. Foliage Diseases. Hardwoods in general have good recuperative power and are not severely damaged by foliage diseases. Leaf diseases are mainly important only when defoliation results or when an attack is so heavy that practically all the leaves are involved and cannot function normally. A single complete defoliation rarely kills hardwoods.

Foliage diseases do affect conifers more seriously than hardwoods. Since conifers depend on 2-7 or more years' growth if lost leaves are not replaced, complete defoliation is usually fatal. Annual killing of the older needles of conifers causes growth to practically cease and generally results in death. Conifers succumb to defoliation more readily than hardwoods and their growth rate is more affected by partial defoliation.

Oak Leaf Blister - During cool wet springs most all species of oak are subject to leaf blister diseases. The white oak is the only species that shows any resistance to the disease. The fungus attacks the leaves of oaks but does little damage to other parts of the tree. The fungus responsible for this disease overwinters in the bud scales of the tree and undecayed leaves on the forest floor. The disease is carried from diseased to healthy trees by means of windblown spores. You can identify the disease by the circular raised areas up to 1/2 inch in diameter. These spots begin as a yellowish-green blister-like spot on the leaves which later turn brown and die. This raised blister-like area on the upper surface results in a depression of the same size on the lower surface. Generally speaking, the infection is not severe enough to warrant control. The leaves remain attached to the tree and there is little noticeable damage. Fungicides are available for the control of this disease in the nursery.

Needle Diseases of Pine - There are several needle diseases of pine that occur in Mississippi, however, two are very prominent. These are needle cast and brown needle spot. Needle cast is a very common disease of conifers throughout the southern United States. Eastern white, loblolly, longleaf, pitch, pond, and shortleaf pines are all susceptible. Pine needles of the current year are infected in the early summer and by winter or early the next spring begin to turn brown at the tips which usually gives the tree a scorched appearance. Later the browning progresses down the needle and the fungus fruiting bodies are produced. These are small black structures found along the edges of the needle. The infected needles are often cast leaving only the new growth. This causes the tree to have a tufted appearance. Controls are seldom needed for this disease in forest stands. Infected trees usually recover and put out new foliage the following year. Nurseries or plantations should not be established in areas where needle cast is prevalent. Fungicides are available for the control of this disease in nurseries.

Brown needle spot is a fungus disease that also causes problems in Mississippi. Initial infection of pine needles results in the development of small circular spots of grey to green color which later turn brown. As the fungus continues to grow, a necrotic area encircles the needle appearing as a brown band. This band will then increase in size, eventually resulting in the death of the needle. Fruiting structures of the fungus develop in the dead area of the needle. Controls are seldom needed for this disease in forest stands. However, when small trees are completely defoliated for several years in a row, death usually occurs. The disease is very damaging during wet years, especially in areas where the fungus has become well

established. The disease can be reduced by control burning during the winter months. Fire burns the diseased needles on seedlings and reduces the amount of available fungus for reinoculation the following year. Also, fungicides will reduce brown spot on the high value trees or in nurseries.

b. Stem Diseases. Serious stem diseases of pine are caused by a number of rust fungi. The mycelium of these fungi is perennial in the bark of the coniferous host and results in various malformations such as galls, cankers, and witches'- brooms. Stem infection usually results in the death of seedlings and saplings. Nearly all of these rust fungi have alternate stages on perennial herbaceous plants or on broadleaved trees or shrubs.

Blister rusts of pine are characterized by the presence of globose, sub-globose, or spindle-shaped (fusiform) swellings or galls.

Southern fusiform rust is one of the most important diseases on southern pines. The rust's most important impact is in nurseries, seed orchards, and young plantations. Millions of dollars are lost each year in southern forests to this disease. Loblolly and slash pines are very susceptible to this rust. Longleaf pine is fairly resistant and shortleaf pine is highly resistant.

The most easily recognized symptom is the spindle-shaped canker on the pine branches or main stem. In early spring these swellings appear yellow to orange as the fungus produces powdery spores. Older stem cankers may become flat or sunken as host tissue is killed. Cankers often girdle trees and wind breakage at the canker is common. Fungus spores from the pine infect oak leaves. Brown hair-like structures, produced on the underside of these leaves in late spring produce spores which in turn reinfest the pine trees, completing a "typical" rust cycle.

Avoid planting highly susceptible species such as slash and loblolly pines in areas of known high rust incidence. In these areas more resistant species such as longleaf or shortleaf pine should be planted. Pruning infected branches will prevent stem infection in young plantations. There should be a minimum of 14 inches between the infected portion and the trunk.

There are more serious canker diseases of hardwoods than of conifers in the United States, but the types of cankers are essentially the same for both groups of trees. There is for the most part no feasible or practical control method for hardwood cankers under forest conditions except removal of the infected trees during thinning operations.

c. Vascular Wilts and Diebacks. Although it is not always possible to make an exact distinction, dieback is characterized by a progressive dying back of a stem from the tip, whereas wilt is characterized by simultaneous death of part or all of a stem accompanied by wilting of the foliage.

Oak Wilt - At least fifty species and varieties of oak are susceptible to this vascular wilt caused by a fungus. This disease has been very damaging in the central part of the United States and at the present time is moving southward. Several confirmed cases have been reported in North Mississippi. The symptoms of oak wilt are very noticeable during the late spring and summer. Some oaks may be killed within as little as two to three weeks with the lower branches of the tree being affected first. Other oaks may require several months or even years before death. Leaves usually turn yellow or brown and dry progressively from tips of the leaves toward the midvein. Premature shedding of the leaves is the most outstanding symptom of oak wilt. Oak wilt is spread over long distances by insects that pick the spores up from diseased trees and carry them to healthy ones. Short-range spread of the fungus may result from the feeding activity of several sap-feeding beetles. The disease may also be spread from tree to tree by means of root grafts. Short distance spread of the disease may be accomplished by severing the roots of all affected trees thus breaking any chance of transmittal by root graft. Another control is to fell all trees in a 50 foot radius of infected trees thus preventing the spread by root graft.

Elm Phloem Necrosis - Elm phloem necrosis is a disease of elm caused by a virus-like organism. The disease has been in Mississippi for a number of years but has become severe only in the last three or four years. The pathogen is transmitted from infected to healthy trees by means of leaf hoppers or root grafts. The early symptoms of the disease appear in the top of the crown at the outer tips of the branches. Here, the elm leaves suddenly wilt, turn yellow and drop. Leaf fall causes the crown to appear sparse. On larger trees the symptoms may appear initially on branches or portions of a branch. The most reliable symptom is a yellow to butterscotch discoloration of the inter bark. The symptom initially appears under the bark of large roots and later spreads to the base or main trunk of the tree. At the present time no effective control is known.

d. Root and Butt Rots. There are so many rots caused by a large number of wood-destroying fungi that it is impossible to do more than discuss the more common and important ones. The →

rots are grouped according to the type of decay. Since in many cases the presence of conks on hardwoods bear a definite relation to the amount of decay in living trees, it is important for foresters to know the more common conks.

Fomes annosus - Hardwoods may be attacked, but damage is usually of minor consequence. In the South, the disease is most serious in pine plantations on sandy soils with low organic matter. All species of southern pine are susceptible. Slash and loblolly plantations are often severely affected.

The disease gains entry into plantations by spore infection of freshly cut stumps during thinnings. The fungus then spreads from the infected stumps to residual trees by growth along the roots to points of root contact. Residual trees usually begin to die within a few years after thinning. The sporophores or fruiting bodies are generally found at ground line or in the root crotch. Pines in initial stages of the disease usually exhibit sparsely foliated crowns. Diseased trees are often found in groups or circular pockets in the stand. The indication of F. annosus decay may include the pink to violet stain of incipient decay, the narrow elongated white pockets and scattered black flecks in the wood of the early decay stages, and the yellow stringy rot of the late stages of decay.

Control includes avoidance of planting on soils of low organic matter and elimination of thinning. Winter thinning will avoid the heavy buildup of spores. Infection following thinning or harvest may be prevented using borax and urea on freshly cut stumps.

3. Weed Tree Species: Since a weed tree is simply a tree out of place, the identification of the weed tree species is contingent upon a precise definition of the forest management objective for stands of mixed tree species. The invasion of pine sites by undesirable hardwood species has become a major problem in forest land management. Since in much of the southern pine region, nature favors forests in which certain hardwood species predominate, control of unwanted or undesirable hardwoods means interrupting the natural climax trend.

Hardwood species can be grouped on the basis of shade tolerance and their place in the successional trend as: Shrubs - sumac, hawthron, wild plum; Miscellaneous hardwoods - persimmon, black cherry, mulberry, sassafras, elm, red maple; Intolerance hardwoods - sweetgum, blackgum, yellow poplar, white ash; Tolerant small hardwoods - dogwood, serviceberry, holly; and Oak-hickory - water, southern red, white, post, and black oaks; hickories.

While shade tolerance and successional stage are important in overall forest management, ill-resistance or sprout classes are more important in forest pest control. Species resistance classes are difficult if not impossible to define because resistance or susceptibility actually depends on (a) method of control, chemical or mechanical; (b) tree and crown size; (c) species; (d) branching characteristics; (e) age; (f) season of year; (g) chemical concentration; (h) formulation carrier, and probably many other soil and climatic factors.

Proper identification of the weed species must be made before the appropriate control method can be selected; however, the dendrology aspects of identification provide little information about the resistance of a woody plant to a chemical or control method. The following resistance categories are intended only as a guide to woody plant identification, since woody plants may be more susceptible to one herbicide than another. When a species is susceptible (S), it can be killed with moderate rates of herbicide. If it is intermediate in reaction (I), it is severely injured or partially controlled by higher rates. If it is resistant (R), control with a herbicide is not feasible.

Species	Herbicide			
	2,4-D	2,4,5-T	Silvex	Ammonium Sulfamate
Alder	S	S	S	S
Ash	R	R	R	I
Basswood	R	I	-	I
Beech	R	R	-	S
Birch	I	S	-	S
Boxelder	S	S	S	-
Cherry	R	I	I	-
Dogwood	I	S	I	-
Elm	R	I	I	S
Blackgum	R	I	I	S
Hackberry	-	S	-	S
Hawthorn	R	I	R	I
Hickory	R	I	I	S
Honey locust	R	I	-	I
Hophornbeam	-	I	-	S
Black locust	I	S	S	I
Maple	R	I	S	S
Oak - black	R	I	-	-
blackjack	R	I	I	-
bluejack	R	I	I	-
live	-	I	-	-
post	I	S	S	S
red	-	I	-	S
turkey	I	I	S	R
white	I	S	I	S
Osage-orange	R	S	I	S
Persimmon	R	I	I	S
Plum	R	I	R	S
Redbud	R	R	S	S
Redcedar	R	R	-	R
Sumac	S	S	-	S
Willow	S	S	S	S

Ring-porous species are more easily killed by complete mechanical stem girdles than diffuse-porous species. Translocation of chemicals from stem injections is much slower in diffuse-porous species than in ring-porous species.

Common ring-porous species - red oak, white oak, black oak, elm, osage-orange, black locust, hackberry, red mulberry, persimmon, ash, honeylocust, hickory, sassafras, black cherry.

Common diffuse-porous species - sycamore, live oak, beech, magnolia, blackgum, yellow poplar, holly, basswood, willow, maple, dogwood, sweetgum

D. BASIC PROPERTIES OF PESTICIDES

1. Insecticides: Insecticides are substances highly poisonous to insects which are applied as dusts, mists, sprays, fumigants, dips, or by pressure treatments to manage an undesirable organism in the environment. Insecticides gain entrance into the insect in one or more of three ways. These methods of entrance are: (a) directly through the body wall, (b) by way of the digestive tract, or (c) via the respiratory system.

   a. Chlorinated hydrocarbon insecticides are generally considered long residual chemicals. Their degradation or breakdown to other compounds may take years. These materials have been and are still used for the control of certain insect pests. The group includes chlordane, BHC, dieldrin, heptachor, aldrin, toxaphene and others.

      Chlorinated hydrocarbon insecticides are not harmful to trees when used according to label directions. They can be harmful, however, to some wildlife forms and animals accumulate them in their fatty tissues.

      Absorption through the skin is the most common hazard when using these materials and probably presents the greater danger during ordinary use. These chemicals act on the central nervous system.

      Symptoms and signs of poisoning in man include headache, nausea, vomiting, dizziness and prostration; in more severe cases convulsions and myoclonic jerks may occur.

   b. Organophosphate insecticides are used for the control of several forest insects and mite pests. In general, they are rapid-acting insecticides that have a short residual life. They usually cause little trouble from residues remaining in the soil. Organosphophate insecticides are not nearly as likely to accumulate in animal tissues as the chlorinated hydrocarbon insecticides. They do, however, tend to be much more acutely toxic to man and other warm blooded animals than chlorinated hydrocarbons. Insecticides in this group include malathion, parathion, Diazinon, naled (Dibrom), Ciodrin, ronnel (Korlan), Delnav, coumaphos (Co-Ral) dimethoate (Cygon), mevinphos (Phosdrin), dichlorvos (DDVP), Ethion, Guthion, Trithion, and others. Some of these are highly toxic, others moderately toxic, while still others are relatively safe. As a result, the precautions necessary to use the chemical will vary. Be sure to observe the precautions on the label.

These insecticides are absorbed by the skin as well as by the respiratory and gastrointestinal tracts. Once they enter the body, they act on the nervous system as cholinesterase inhibitions. The inhibitions of this enzyme will cause an overstimulation of the nerves or nerve functions, and produce the following symptoms in man:

Symptoms and signs of poisoning in man by these insecticides include: headache, blurred vision, watering of the eyes, weakness, cramps, nausea, sweating, diarrhea, nervousness and chest discomfort. A reliable diagnosis, however, cannot be made on the basis of one or two telltale symptoms or physical findings, but rests instead upon the proper interpretation of a combination of data including history of exposure to the insecticides, symptoms and physical findings, laboratory results, etc.

c. Carbamates - This group of insecticides has the same general effects as the organic phosphates.

Insecticides in this group include carbaryl (Sevin), Baygon and Zectran. Like the organic phosphate group, they inhibit the enzyme cholinesterase. They are absorbed through the skin as well as respiratory and gastrointestinal tracts. Symptoms of carbamate poisoning include watering eyes, urination, diarrhea, muscular twitching, increased respiration and salivation, pupil constriction, poor coordination and vomiting. These may be confused with symptoms of organic phosphate insecticide poisoning.

d. Systemic insecticides are predominantly of the organic phosphate type, however, they are translocated within plants. Once absorbed by the plant they are often synthesized into other compounds of varying toxicity from the original insecticide. This group includes dimethoate (Cygon), which is used for the control of pine tip moth and various coneworms, as well as bidrin, systox, Di-Syston, and many others.

2. Fungicides: Although fungicides are commonly used in the control of plant diseases in general, their application to the control of forest tree diseases is limited, except in nurseries, because of the cost. They are applied either as dusts or as sprays. In recent years a large number of new fungicides have been developed and marketed under many trade names thus creating problems of identity and considerable confusion. Relatively few of these new chemicals have yet been tried against pathogens of forest trees. Inasmuch as the results of tests of fungicides against these diseases are appearing frequently, it is well to have the latest information for a particular disease if a control program is planned. The best sources of such information are the state and Federal agricultural experiment stations.

Those fungicides used in forest tree cultures have little effect on the immediate environment. Persons working with Thiram treated seeds should avoid alcohol consumption while in the proximity of those seed. Alcohol in the blood plus inhibition caused by Thiram dust can lead to acute medical problems.

3. Herbicides: A herbicide is a chemical used to kill or inhibit growth of plants. To be effective, herbicides must enter the plant. The two most common points of entry in plants are through the leaves and through the roots. Some chemicals are effectively absorbed through the stems and also some seeds may absorb the herbicide.

Herbicides are grouped, on the basis of use, into selectives and nonselectives and, on the basis of mode of action, into contact, translocated, and sterilant chemicals. Selective herbicides are those that kill certain weed species without seriously injuring the desirable plants among which they are growing. Nonselective herbicides kill vegetation with little discrimination. Resistant species are physiologically resistant to the chemical.

Contact herbicides kill the tissues that are wetted with the spray. Whether the plant dies or recovers depends on whether it has a protected growing point. Perennials usually have underground buds that will regrow.

Translocated chemicals are absorbed by the leaves on stems or by the roots and move through the vascular system to leaves, buds, and root tips. When absorbed by the leaves and stems, the chemical is commonly moved with the food materials that were manufactured in the leaves and stems. When absorbed by the roots, it moves in the water-conducting tissue. The growth-regulator type of translocated herbicide is a synthetic compound that behaves like a plant hormone. It accumulates mostly in areas of rapidly dividing cells, upsetting the normal metabolism of the plant and causing death of the cells. Foliar applications of translocated herbicides are of great practical value, because small amounts are effective and they can be applied in small volumes of water or oil.

A soil-sterilant herbicide makes a soil incapable of supporting higher plant life, but it does not necessarily kill all life in the soil, such as fungi, bacteria, and other micro-organisms. Its toxic effects may remain for only a short time or for many years. Residual toxicity depends on: (1) the chemical and its rate of decomposition or leaching, (2) the colloidal and chemical content of the soil, (3) species tolerance, and (4) rate of application.

a. Phenoxy Compounds include 2,4-D, 2,4,5-T, and silvex. In the acid form, these herbicides are only slightly soluble in water. For commercial use, they are formulated as esters,

which form milky emultions with water and also dissolve in light oils, or as water-soluble salts. The amines are the most widely used salts. They are easily soluble in water and are commonly sold in liquid form. There are also sodium and ammonium salt formulations that are sold as water-soluble powders, but they are not so effective as the amine salts on hard-to-kill species or on weeds that are in bud stage and beyond. All of the salts are practically nonvolatile.

Although low-volatile esters vaporize less rapidly than high volatile esters, both types are volatile at high temperatures. Drift can occur with any of the formulations if the spray is in very fine droplets or mist and there is a wind.

When an attempt is made to kill plants by application of phenoxy type herbicides to their foliage, the chemical will penetrate the cuticle of the leaf, move across the mesophyll cells into the vascular system of the plant, and there be moved in the phloem to the roots. Before a plant is killed, three fundamental processes must take place. The chemical must be absorbed, it must be translocated, and it must produce a lethal effect on the growing tissue of the plant.

b. Ammonium sulfamate, designated as AMS, is a granular material that is very soluble in water and that breaks down rapidly in moist soil. It is nonflammable, nonvolatile, and strongly toxic to plants.

Ammonium sulfamate is commonly substituted for the phenoxy compounds in areas where crops sensitive to these chemicals are grown. It is a contact, nonselective herbicide effective over a wide range of conditions and species. It is especially effective on poison-ivy, poisonoak, and poison-sumac. Ammonium sulfamate, in the crystal form or in concentrated solutions, is successfully used for stump applications. It is corrosive to metals, especially brass and copper. Stainless steel, aluminum, and bronze are resistant. Spray equipment must be protected, but corrosion of fences, guy wires, and telephone wires is negligible.

It is not effective against eastern redcedar, snowbrush, and Turkey oak.

c. Arsenicals are among the cheapest herbicides, but they must be handled carefully. Two groups of arsenicals are used for killing weeds: the inorganic and organic.

The inorganic arsenicals include sodium arsenite, lead arsenate, and calcium arsenate. They are all highly poisonous to man and animals if swallowed. Their effectiveness for weed control depends on their arsenic content, which is commonly expressed in percent of arsenic trioxide.

The organic arsenicals are considerably less toxic than the inorganic arsenicals to humans and livestock, but they are harmful if swallowed. Organic arsenicals are applied at a postemergence for the control of crabgrass in turf and cotton. Two of the more common organic arsenicals are MSMA and DSMA.

d. Soil sterilants. Soil sterilants are formulated as water-dispersible powders, granular products, liquids, and pellets. With the exception of the pelleted and granular materials, the liquid formulations are applied as suspensions or solutions in relatively large volumes of water and require agitation in the spray tank. Bromacil, prometone, tandex, monuron, and sodium clorate are common soil sterilants.

Although soil sterilants do not move far laterally in the soil, they may be washed down the surface of slopes to kill vegetation below and they leach deeply enough to reach the roots of trees, shrubs, and other deeprooted plants growing under the treated area. All soil sterilant chemicals can irritate eyes, nose, throat, and skin.

e. Fumigants. Fumigants are volatile at ordinary soil temperatures and at atmospheric pressure. They are applied to the soil not only to kill the weeds but in some instances to kill soil micro-organisms, nematodes, and insects. There are three general classes: (1) Those that are mixed with the surface soil, sealed in with water, and do not require a gasproof cover; (2) those that do require a gasproof cover; and (3) those that are injected into the soil, such as methyl bromide.

f. Herbicidal oils. These compounds are used as vegetation topkillers, as solvents in the formulation of herbicides, and as carriers for herbicidal chemicals. Oils that kill by contact should not be used as solvents or carriers of translocated herbicides, since a quick kill of the conducting tissue prevents translocation of the chemical.

There are five general classes of oils: (1) Medium-to-heavy, viscous, aromatic oils for general weed control: diesel oils, burner oils, low-grade oils, and oil extracts. They are safe to use and noncorrosive; (2) Light oils not toxic to all plants and used for selective weed control: stove oil, kerosene distillate, Stoddard solvent, and mineral spirits; (3) Special oils resulting from the manufacture of gasoline and formulated especially for weed control. Many oils of this type are now available; (4) Fortified oils, whose herbicidal properties have been increased by the addition of other herbicides such as pentachlorophenol; (5) Emulsifiable oils, oil solutions containing a surfactant capable of causing emulsification upon mixing with water. The oils, in general, are moderately toxic to animals, but kerosene types are highly toxic.

g. Picloram. Picloram has high phytotoxicity, is easily absorbed by roots and foliage, is truly systemic, and is degraded slowly. It is absorbed by leaves, stems, and roots and is translocated within the plant. Picloram is absorbed by soil colloids and the degree of leaching is universely correlated to the absorption and water-holding capacity of the soil. It is most easily leached through sandy soils and coarse soils low in organic matter. In contrast, it is leached with greatest difficulty through soils high in organic matter and clay content. Picloram is very persistent in soils, but subject to slow degradation by micro-organisms. Phytotoxicity may often be detected well over 1 year after application.

Picloram is effective on most perennial, broadleaf, herbacious weeds, and many woody species; however, grasses are resistant. On some species it is 10 times as potent as 2,4-D. It may be applied to the foliage, bark, and cut surfaces of woody plants as a liquid spray and to thick stands of brush as pellets.

E. CONCENTRATION AND PREPARATION OF CHEMICAL MIXES

1. Expressions of Chemical Concentration: The active ingredient is that part of the chemical formulation which is directly responsible for the pesticide effects. The proportion or concentration of the active ingredient in a formulation is commonly expressed as acid equivalent or percent concentration.

Acid equivalent refers to that part of a formulation that theoretically can be converted to the acid. The percent active ingredient or acid equivalent is given on the label. To calculate the weight of the commercial product required, this formula may be convenient:

$$\frac{\text{Chemical weight (vol.) to be applied}}{\text{\% active ingredient (as decimal)}} = \text{Weight (Volume) of commercial material required.}$$

For example, to apply 15.0 lbs. of active ingredient per acre from a commercial product, that is 75% active ingredient,

$$\frac{15.0}{0.75} = \text{20.0 lbs. of the commercial product should be used.}$$

Liquid formulations may show on their labels both the percent active ingredient or acid equivalent, and the weight per gallon. These formulations may be calculated and weighed in the same manner as dry forms; however, it is easier to calculate by liquid measure.

To calculate the amount of liquid herbicide when the rate is expressed in pounds per acre, the following formula may be used:

$$\frac{\text{Rate in lbs./acre}}{\text{lbs. of herbicide per gallon}} = \text{gallons per acre}$$

For example if the rate is 3 lbs. per acre and the herbicide contains 4 lbs. acid equivalent per gallon, then

$$\frac{3.0}{4.0} = .75 \text{ gallons per acre}$$

2. Formulations of Pesticides: A formulation contains the pesticide in a form that can be dissolved or suspended in a carrier and distributed in solution or suspension by sprayers, distributed dry by dusters or in granules by spreader, or easily vaporized for fumigation. A solution is a physically homogeneous mixture of two or more substances whereas an emulsion is one liquid dispersed in another liquid, each maintaining its own identity.

   a. Water-soluble concentrates are readily dissolved in water to make a spray. They are often sold as solids. Dalapon, sodium salt of 2,4-D, and amitrole are examples. They are also formulated as liquids -- amine salts of 2,4-D and the sodium salts of PCP and endothall.

   b. Emulsifiable concentrates are liquids in which the chemical is dissolved in one or more organic solvents such as oil or benzene and to which an emulsifier is added. When the emulsifiable concentrate is added to water and agitated, the mixture is broken into fine droplets. The emulsifying agent causes the fine droplets of oil to be suspended in the water to form an emulsion. The esters of 2,4-D, 2,4,5-T, and silvex are examples.

   c. Oil-soluble concentrates are similar to emulsifiable concentrates, but they do not contain an emulsifier. They do not mix with water, but they can be diluted with fuel oil or kerosene or applied without dilution.

   d. Wettable powders or waterdispersible powders are generally formulated from chemicals that are insoluble or soluble with difficulty in oil or water. They are finely ground with or without a powdered diluent. A wetting agent is added to keep the particles from floating, and a dispersing agent is added to keep the material in suspension.

e. Dusts are dry pesticides plus a filler. Dusts are not widely used in forest pest control.

f. Granules and pellets are forms of herbicides in which the chemical is impregnated upon vermiculite, attaclay, or similar carriers. They can be prepared by spraying the pesticide on the carrier or by adding the core material, such as vermiculite, to the original dry powder. Then a pill-rolling technique with binders is added to produce pellets, or the powder plus binders and water is extruded, chopped, and dried to produce grains or pellets. Simazine, 2,4-D, and an increasing number of herbicides are formulated as pellets.

g. Fumigants contain the base chemical and sometimes a lachrymal additive that serves as a warning that poisonous vapors are present. Methyl bromide is an example.

h. Surfactants is a general term for wetting agents, spreader--stickers, and other materials that alter the physical and chemical characteristics of a spray solution. A surfactant may serve as an emulsifier, improve suspension and dispersion of insoluble powders in water, or improve wetting through the reduction of surface tension.

3. Mixing of Pesticides: Mixing spray materials correctly involves calculations of the proper amounts of pesticide and diluent and procedures for mixing. Never pour concentrated pesticides into an empty tank. Either fill the tank half full, add the chemical, agitate, and complete the filling or start filling and add the chemical as the filling is continued.

a. Water sprays. When using a soluble powder or crystals, fill the tank half full of water. Add the chemical slowly, and stir to dissolve it completely. Then complete the filling.

b. Emulsions. Since emulsions are suspensions and not solutions, they require constant agitation. If no additional oil is to be used, start running water into the empty tank and slowly add the pesticide formulation with continuous agitation. The chemical should all be added by the time the tank is one-third full.

If oil is to be used, premix the pesticide and the oil in a separate container. Do not allow any water to get into this mixture or it may jell. Fill tank one-third full of water, add premixed oil and herbicide, and continue filling.

When an invert emulsion is used, add water slowly to the premixed pesticide-oil solution under constant mechanical agitation; circulating with bypass is insufficient. Invert emulsions may separate readily on standing.

c. Oil sprays. Add esters of 2,4,5-T, 2,4-D, or silvex, or other oilsoluble herbicides to the required amount of oil and mix thoroughly in the tank. This can be done at any time before spraying, since the spray does not separate. Do not let any water or any oil-water mixture get into the chemical formulation or the herbicide-oil mixture or it may jell.

d. Suspensions. Waterdispersible powders mix readily with water but do not dissolve. There are two methods of mixing: (1) add the powder slowly to water, with agitation -- it should not be added to an empty tank -- or (2) make a thin water slurry of the required amount of material before it is added to the water in the tank. A thorough job of mixing will help the agitator do its job more efficiently.

When a water-soluble chemical is to be mixed with a water-dispersible powder, dissolve the water-soluble chemical in the water before adding the powder.

F. BASIC METHODS OF APPLICATION

Every applicator of pesticides should be constantly aware of the 4 p's: proper pesticides, properly applied, at the proper time, and in the proper place. No single chemical or method of application is suitable for all forest or site conditions. Planning your program in advance of application will provide the most adequate control at the least cost per acre. One must assess a given problem carefully, then choose the proper method of application, and later evaluate the results as accurately as possible. The application of pesticides should only be recommended when they are economical, environmentally safe, effective, and can be properly applied.

1. Sprays: Spraying is the most common method of applying pesticides. Solutions, emulsions, and wettable powders are usually applied as sprays with water as the more common diluent or carrier. Oils are frequently used both as a herbicide and as a carrier. Sprays can be applied uniformly, since relatively small quantities of pesticide can be diluted sufficiently to permit even coverage. With properly designed and properly operated equipment, spray drift can be reduced to a minimum. Sprays can be accurately directed to a given area, either on the soil or on the plant.

Sprayers are classified as low-volume sprayers or high-volume sprayers. Low-volume sprayers apply less than 30 gallons of total spray per acre. Uniform application is extremely important with both low and high volumes.

Sprays can be applied from a sprinkler can, hand sprayer, or a power sprayer. The power sprayer may be a small portable unit, a tractor or truck mounted sprayer, or an aircraft mounted sprayer.

The nozzle is probably the most important part of the sprayer. Other parts exist only to help the nozzle operate properly, uniformity of application, rate of application, and spray drift as influenced by droplet size are all largely determined by nozzle design and conditions of operation.

Most sprayers used in forest pest control are of the low-volume type; however, the spray from them may be directed or undirected. Directed sprays are used in insect, disease, and woody plant control to saturate specific plant foliage, portions of the stem, or soil areas. Undirected sprays such as that from power mist blowers and aerial application are primarily used to apply herbicides for woody plant control. With mist blowers and aerial application, relatively low volumes (3-10 gallons per acre) with high concentrations are usually applied.

The time, temperature, and weather factors deserve much consideration particularly when spraying herbicides. Since most herbicides will cause considerable damage to crops, it is necessary that all precautions be taken to prevent drift. Wind velocity is critical in mist blowing and aerial application. No spraying should be done if the wind velocity is 10 miles per hour or more. Many herbicides will volatilize at temperatures of 80 degrees F or higher. A calm, cool day of high humidity is ideal for spraying herbicides.

2. Granular Application: Some chemicals, particularly herbicides, are applied at high enough rates that crystals of the chemical itself can be applied uniformly. Granular materials can be spread by hand, or by mechanical spreaders resembling seed or fertilizer spreaders.

   Granular materials have three advantages over sprays: (a) water is not needed, (b) costly spray equipment is not required, and (c) large granules tend to fall off the foliage of valuable plants without injury. The major disadvantages of granules are: (a) they are easily moved by water and (b) application is seldom as uniform as with sprays.

   In a soil treatment, the herbicide is placed on the ground around the plant; injected into the soil approximately 4 inches below the surface, adjacent to the stem; or spread over the entire vegetated area. Herbicide applied in moderate concentrations can be effective for controlling woody vegetation, but at high concentrations it can render the soil sterile for a number of years. Soil treatment has not found widespread use in timber stand improvement, primarily because it is too expensive.

3. Dusts: Dusts are not widely used in forest pest control because of the drift hazard and non-uniformity of application.

4. Mechanical - Chemical Application: A combination of mechanical and chemical methods are used to weed forest stands of undesirable trees competing for the light, moisture and nutrient requirements of the more desirable species.

In general, these mechanical-chemical methods involve the penetration of the bark and cambium layers of the main stem with a sharp mechanical tool such as an axe or a cutting bit and the release of a herbicide into the cut surface. The herbicide is translocated within the tree's conductive tissues to the crown and cambial areas. These methods may be used at any time of the year and on species that are hard to kill by foliage sprays. Since mechanical chemical methods involve individual stem treatments, a non-selective herbicide can be used to selectively remove individual trees or particular species without harmful environmental effects.

The cut-surfaces may form a single continuous line of overlapping downward axe cuts in the case of the continuous full girdle or the axe cuts may be spaced several inches apart as with the spaced cut frill girdle or the frill-with-notches methods. The frills are then saturated with the herbicide or the notches filled with dry crystals.

Where more than a few hundred stems per acre must be treated, a more rapid and cheaper method that has gained considerable popularity is the tree injector. Most tree injectors are hollow cylinder tools with a cutting bit in one end and either a hand operated or automatic triggering mechanism for releasing the chemical into the cut made by the bit. The injector is thrown at the base of the tree at an angle of approximately 60 degrees with the ground. Injections are spaced around the base of the tree for most species or overlapped for hardto-kill species.

Both 2,4-D and 2,4,5-T have been used in injectors; however, the amine salt formulation of 2,4,5-T has been more effective than the ester formulation or 2,4-D. The effectiveness of the amine salt of 2,4,5-T over the ester is due, in part, to the increased vertical translocation above tree injections to the crown and possibly to phloem translocation away from the foliage to other parts of the tree, including movement down the stem to kill the underlying cambium.

G. PROTECTING THE ENVIRONMENT

1. Aquatic Environment - Pesticides find their way into aquatic environments from areas that have been treated to control unwanted plant and animal pests. While pesticides may be present in very dilute quantities, they tend to be actively or passively magnified or concentrated by way of suspended particles, organic and inorganic, which are dispersed in water.

   Pesticides enter the aquatic environment by four principal mechanisms:

   a. Agricultural Runoff: This is one of the principal mechanisms and is the most widespread source of pesticides entering the aquatic environment.

   b. Point Source (e.g. Industrial Effluents): Pesticide contamination of the aquatic environment by point sources such as industrial effluents may result in immediate biological catastrophies or in long-term adverse effects.

   c. Leaching: Ground water or subsurface water may also be contaminated by pesticides. There are examples of the contamination of wells and other municipal water supplies.

   d. Spillage, Accidents, and Careless Handling: Pesticides may also enter watercourses through inadvertent spillage, for example, around industrial sites. There are many other ways pesticides enter water which fall in this category; e.g. cleaning of application equipment in streams, and the careless aerial application of pesticidal chemicals.

   The organic phosphates and chlorinated hydrocarbon insecticides pose a serious threat to fish if allowed to enter the aquatic environment. Some of these chemicals rank as the most toxic compounds to fish man has ever discovered. The chlorinated hycrocarbons pose the greater threat because of their persistence.

2. Soil and Water: Because of the many different chemical compositions of pesticides, one might expect them to vary considerably in the way they react with soil, water, and other substances. Pesticides vary widely in their solubility in water, stability in the presence of sunlight, resistance to oxidation, resistance to microbial degradation, etc. Some pesticides are bound very tightly to the soil by a physical phenomenon known as adsorption. Certain materials in the soil will adsorb some of the organic compounds so strongly that their insecticidal action is nearly destroyed.

3. Drift and Volatilization: Chemicals may drift through the air from the area of application and cause considerable injury if they contact susceptible plants or animals. Movement through the air may result from spray drift or volatilization.

   Spray drift is the movement of airborne spray particles. The amount of spray drift depends upon (1) size of the droplets, (2) amount of wind, and (3) height above the ground that the spray is released. Size of the droplet will depend primarily upon pressure, design of the nozzle, and surface tension of the spray solution. In general, low pressures tend to produce large droplets and high pressures small droplets. Small nozzles tend to produce small droplets and solutions possessing low surface tension tend to produce small droplets.

   Volatilization refers to the tendency of the chemical to vaporize or give off fumes. The amount of fumes or vapors given off is related to the vapor pressure of the chemical.

   Vapor drift is the movement of these vapors or fumes. The vapors may damage susceptible crops, or may simply reduce, through loss, the effectiveness of the herbicide treatment.

   Volatility of 2,4-D has perhaps received more attention than any other chemical. The amine and sodium salts of 2,4-D have little or no volatility hazard. The ester formulations vary from low to high volatility.

4. Disposal of Pesticides and Pesticide Containers: The disposal of pesticides and pesticide containers requires at this time more of a recognition of the problem than a specific solution. The need for improvements in methods of solid waste management, particularly in disposal, is nowhere more striking than in the disposal of hazardous wastes, including pesticides and pesticide containers. Improper handling of these wastes can, and often does, result in danger and even death to people and animals not involved in the dispersing of the materials. The variations in toxicity, life, degradability and concentration of pesticides pose a serious problem in disposal. Because of the variations, each situation regarding major disposal must be handled on its own need. Detailed information on the disposal of pesticides and their containers can be obtained through your County Health Office.

H. RECOMMENDED PRACTICES FOR FOREST PEST CONTROL IN MISSISSIPPI

Herbicides Registered by Environmental Protection Agency For Woody Plant Control

(as of March 15, 1974)

Important: Be sure to read labels for dosage and safety precautions. Information on registered pesticides for use in black walnut plantations is also available. Write to Dr. Larry Abrahamson, Southeastern Area, State and Private Forestry, 1720 Peachtree Road, N.W., Atlanta, Georgia 30309.

HERBICIDE	APPLICATION METHOD	HOST
2,4-D Amine	Foliage & stem application	Non-cropland Pasture & rangelands
	Stump application	Non-cropland - fresh cut stumps
	Tree injection method	Non-croplands - forest (pine release)
2,4-D, LV esters	Foliage & stem application Aerial application	Non-cropland Pastures & rangelands
2,4-D esters	Foliage & stem application Aerial application	
2, 4-D inverted emulsion 2,4-D + 2,4,5,-T inverted emulsion 2,4-D + Picloram inverted emulsion (Non-cropland only)	Aerial application Foliage application	Non-croplands Forestry uses Pine release Site preparation Rangelands
2,4-D Amine + Picloram	High volume foliage & stem application Low volume or aerial application (thickening agents should be used also)	Non-cropland
	Tree injector method Frill or notch treatment Girdle treatment	Non-cropland + forest
2,4-D + 2,4,5-T Amines	Foliage & stem treatment Aerial application	Rangelands Non-croplands
	Basal bark treatment Stump treatment	Non-croplands
	Frill or notch treatment	Non-croplands - trees larger than 6" DBH
2,4-D + 2,4,5-T LV esters	Aerial application Foliage & stem treatment	Mesquite Non-croplands - rangelands
	Basal bark treatment	Mesquite Non-croplands - rangelands - brush & trees less than 6" DBH
	Stump treatment	Mesquite Non-croplands - rangeland - fresh cut stumps
	Frill or notch treatment	Mesquite Non-croplands - rangelands - trees larger than 6" DBH
	Dormant application	Mesquite Non-croplands - rangelands

HERBICIDE	APPLICATION METHOD	HOST
2,4,5-T LV esters	Aerial application	Pine release
	Foliage & stem application	Mesquite
		Non-cropland - stumpland
	Basal bark application	Pine release
		Mesquite
		Non-cropland stumpland - brush & trees less than 6" DBH
	Stump application	Pine release
		Mesquite
		Non-cropland-stumpland-fresh cut stumps
	Frill or notch treatment	Pine release
		Mesquite
		Non-cropland - stumpland - larger trees (6+" DBH)
	Dormant cane broadcast	Pine release
		Mesquite
		Non-cropland - stumpland
2,4,5-T Amine	Foliage & stem application	Non-cropland
	Aerial applications	Rangeland - pastures
	Basal bark treatment	
	Stump treatment	
	Frill treatment	
2,4,5-T + Picloram	Basal bark treatment	Rights-of-ways
	Dormant stem treatment	Non-croplands
MCP Amine	Foliage & stem application	Non-cropland
	Aerial application	Rangelands
Silvex (2,4,5-TP)	Aerial application	Pastures & rangelands
	Foliage & stem application	Non-croplands
	Stump application	
Picloram	Broadcast & spot treatment (granules)	Rights-of-ways
		Non-croplands
Ammonium sulfamate (Ammate)	Foliage & stem application	Pastures & rangelands
		Non-crop areas
	Stump treatment	Pastures & rangelands
		Non-crop areas - fresh cut stumps
	Frill or notch treatment	Pastures & rangelands
		Non-crop areas - undesirable hwd. trees
Bromacil (Hyvar®)	Broadcast & spot treatments	Non-cropland areas
TBA (trichlorobenzoic acid)	Foliage & stem application (woody vines, as kudzu, also)	Non-cropland
Amitrole	Foliage & stem application (poison ivy & oak and woody vines, as kudzu)	Non-cropland
Dicamba (Banvele)	Aerial application	Pastures & rangelands
	Foliage & stem application (woody vines as kudzu also)	Non-cropland
	Tree injection	Forest stands
Dicamba & 2,4-D or 2,4,5-T Amine or LV esters	Aerial application	Pastures & rangelands (Tex., Okla. & N.Mex. only)
	Foliage & stem application	Non-cropland
	Basal bark application	
Cacodylic acid	Tree injection	Forest stands
	Frill or notch application	

Note: Pesticides should never be applied if they endanger humans, livestock, crops, beneficial insects, or fish and wildlife. They should not be applied when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues. Since the registration of pesticides is under constant review by state and federal authorities, a responsible state and federal agency should be consulted as to the present status of any pesticide before its use.

WOODY PLANTS

General recommendations for applying herbicides to forest trees, brush, and woody vines.

A) CUT-SURFACE TREATMENTS: FOREST TREES

Application Technique	Target Species	When to Apply	Herbicide and Rate (Active Chemical)	How to Apply
1) Frill Girdle (continuous cuts)	Trees 5" to 6" in diameter and larger.	Any season, but spring and growing season treatments are most effective.	(1) 2,4-D and/or 2,4,5-T (ester) 16 lbs/100 gal diesel fuel. (2) ammonium sulfamate (AMS) 8 lb/2 gal water. (3) 2,4,5-T (amine) 16 lbs/100 gal water. (4) picloram + 2,4-D - (Tordon 101R)	Apply herbicide to overflowing in single line of overlapping downward axe cuts completely around trunk. Frills made waist high above ground level are most convenient. Do not remove chips made by axe. No chemical needed for trees over 14" in diameter. Spray or paint surface to wet with concentrate.
2) Frill Girdle (spaced cuts)	Trees 5" in diameter and larger.	Any season, but spring and growing season treatments are most effective.	(1) 2,4-D and/or 2,4,5-T (amine) 1 ml per cut from 4 lb/gal. (2) dicamba - 4 lb/gal diluted 1 to 1 with water. (3) picloram + 2,4-D - (Tordon 101R)	Apply 1 ml in each axe cut about waist high around tree, spaced 2" edge to edge. 2,4-D and/or 2,4,5-T more effective April to August on all species. Spray or paint surface to wet with Tordon 101R. Picloram + 2,4-D or dicamba effective any time on most species. Do not apply picloram or dicamba in the root zone of desirable very susceptible species, such as yellow poplar or pine.
3) Injector (spaced cuts)	Trees 1" in diameter and larger.	Most effective April to August on all species.	(1) 2,4-D (amine) - 4 lb/gal material. (2) picloram + 2,4-D - (Tordon 101R) (3) dicamba - 4 lb/gal diluted to 1 to 1 with water. (4) 2,4-D + 2,4,5-T (ester)-40 lb/100 gal oil.	Use a special tree injector calibrated to deliver .75-1.0 ml per cut, space cuts 2" apart (edge-to-edge) at base of tree. Use on all species any time of year. Overlap injector cuts on hard-to-kill species, such as hickory, dogwood, blue beech, and ash.
4) Hypo-Hatchet (spaced cuts)	Trees below 8" in diameter. Hardwoods 8" to 16" in diameter require 1 cut per inch of diameter during all seasons. Effective on blue beech; maple, hickory, and ash.	Most effective in summer and fall with spaced injections.	(1) MSMA or cacodylic acid. (2) Same herbicides as injector recommendations above.	1.3 ml per cut depending upon species and season.

Woody Plants, Continued

Application Technique	Target Species	When to Apply	Herbicide and Rate (Active Chemical)	How to Apply
5) Stump	Sprout control on hardwood cut stumps, particularly on species that sprout profusely; oaks, maple, beech, hickories. No chemical needed for trees over 14" in diameter.	Any season, but most effective as soon as possible after cutting.	(1) 2,4-D and/or 2,4,5-T (amine) - 20 lbs/100 gal. (2) ammonium sulfamate (AMS) dry crystals. (3) picloram + 2,4-D - (Tordon 101R) (4) 2,4,5-T (ester) 20 lbs/100 gal of diesel fuel.	Apply with low volume knapsack sprayer using solid cone nozzle of medium orifice. Paint or spray flat, freshly cut stump surface with herbicide, making sure that spray runs down sides to root collar. Trees smaller than 4" in diameter can be V-notched with an axe and crystalline ammonium sulfamate (AMS) sprinkled into notch - 1 oz. per inch of stump diameter.
B) BARK, FOLIAGE, AND SOIL TREATMENTS BRUSH AND FOREST TREES				
1) Basal Bark	Scattered brush or "clumps" of hardwood brush and small trees. Can be used on species resistant to a first foliage spray. Expect poor control on root suckering species; black locust, hickories, and sassafras. Best results on trees less than 3" diameter.	Any season	(1) 2,4-D + 2,4,5-T or 2,4,5-T or 2,4-D + 2,4 DP - 16 to 24 lb/100 gal oil (esters). (2) dicamba 3 lb + 2,4,5-T - 12 lb/100 gal oil (Use oil soluble formulation). (3) 2,4,5-TP (ester) - 12 to 16 lbs/100 gal oil.	Drench lower 12" to 15" of plant. Density of brush will determine rate/A.
2) Foliage Spray (low volume, aerial)	Large tracts of mixed brush and hardwoods growing on utility lines and rights-of-way. Adaptable for conifer release on forest lands and for range and pasture establishment. Site preparation in advance of seeding or planting forest trees.	All hardwood species during late spring and summer. Apply during growing season from full leaf expansion to September 1.	(1) 2,4-D + 2,4,5-T - 2 to 4 lb in 5 to 10 gal water per acre. (2) 2,4,5-T (ester) - 2 lbs/5-10 gal water per acre for pine release. (3) 2,4,5-TP (ester) - 8 to 16 lb/10-30 gals of water per acre. (4) 2,4,5-TP (ester) - 2 lbs/10-15 gals water in pine stands after spring growth and "hardening off".	Use aerial application, low volume sprayer or powered mist/blower. Good root collar coverage is essential. Use drift control agent in mixture. Do not use diesel fuel or petroleum in mixture when applying over pine reproduction or seed trees. Note: A volume of diesel fuel equivalent to the volume of the herbicide can be added to the mixture in place of that volume of water to increase leaf absorption in late growing season. Check the label.

Application Technique	Target Species	When to Apply	Herbicide and Rate (Active Chemical)	How to Apply
3) Foliage Spray (high volume, ground)	Scattered brush or "clumps" of hardwood brush. Can be used on species not controlled by prior sprays such as maple, oak, ash and persimmon growing along fence rows, highways and rights-of-way and other non-crop areas.	Late spring and summer from time foliage is fully developed. Dormant season ineffective.	(1) 2,4-D + 2,4,5-T - 8 to 24 lbs/A applied in 10 to 30 gals of water. (2) 1.25 lb dicamba + 2.5 lb 2,4-D or 2,4,5-T in 100 gals water. (3) for back pack sprayer - 2,4,5-T (ester), 4 lbs/100 gals water. (4) 2,4,5-TP (ester) at 3-4 lbs/100 gals water.	Apply uniformly over top of brush as a coarse spray. Ash is resistant to all listed herbicides. With back pack sprayer, wet all foliage of plants to run off.
4) Soil Application (dry materials)	Individual trees or "clumps" of brush of all species and sizes. For release of underplanted trees (stand conversion), follow-up on sprayed rights-of-way, pasture development and selective control of roadside woody plants.	Apply on all species during any season, but late winter and early spring applications are most effective. Do not apply to steep slopes or wet soil surfaces.	*Individual trees: Place 10% picloram completely around base of tree 1 teaspoon/inch tree diameter; place 10% bromacil pellets completely around base of tree 2 teaspoon/inch tree diameter.* Clumps of brush: 10% picloram 5 to 10 lb/A. Increase rates on fine textured soils (clay, etc.)	Apply as pellets, granules or beads. For release of underplanted trees use grid or row methods; for non-selective control, apply broadcast by hand or cyclone seeder. Understory witch hazel, sassafras and ironwood are most susceptible to picloram. Do not apply in root zone of desirable plants.
5) Foliage Spray (non-selective)	All unwanted small trees, shrubs and brush in advance of planting or seeding.	Late spring, summer and early fall.	(1) 2,4-D + 2,4,5-T - 4 to 8 lb in 10 to 30 gals water. (Per Acre). (2) 2,4,5-T - 4 to 12 lb in 10 to 30 gals water. (Per Acre). (3) 2,4-D + 2,4-DP - 2 lbs of each (1 gal Weedone 170) plus 1 qt of MSMA (Transvert) in 10 gals water. (Per Acre). (4) 2,4,5-T (Envert-T) - 2 to 4 lbs plus 1 to 2 pts Transvert in 9 to 15 gals of water. (Per Acre).	Apply aerially or from ground or tractor-mounted sprayer from full leaf expansion to September 1. If permitted burn in winter to eliminate dead debris.

Woody Plants, Continued

Application Technique	Target Species	When to Apply	Herbicide and Rate (Active Chemical)	How to Apply
C) WOODY VINES				
1) Poison Ivy	Climbing or procumbent vines.	Late spring applications most effective. During dormant season saturate stems with 5% 2,4,5-T in oil carrier.	(1) Foliage spray, amitrole (50%) 1 lb in 25 gals of water. (2) 2,4,5-T (1/2%) in water. (3) ammonium sulfamate (95%) 1 lb/gal of water. (4) picloram pellets (10%) at 4 to 6 lbs/A broadcast over root zone.	Thoroughly wet all plant surfaces and woody stems using knapsack-type garden sprayer. Spot treat regrowth as required. Note: Use picloram only where desirable trees with root zone in the treatment area are expendable.
2) Japanese Honeysuckle	Climbing or procumbent vines.	Foliage spray in late spring or summer. Control during dormant season is difficult.	(1) Foliage spray, amitrole (50%) 2 lbs in 25 gals water. (2) 2,4-D or 2,4-D + 2,4,5-T - 2 to 3 lbs/100 gal water.	Apply as foliage spray, thoroughly wetting all foliage and stems. Density of cover will determine volume of spray per acre. Spot treat regrowth as required. Generally requires a follow-up or second application.
3) Grape Vines	Grape tangles and large climbing vines.	Foliage spray in June or July. During dormant season use basal spray.	Grape tangles: Foliage spray with 2,4,5-T - 4 lb/100 gal water. In dormant season, basal spray with 2,4,5-T - 16 lb/100 gal oil. Large climbing vines: Basal spray with 2,4,5-T - 16 lb/100 gal oil.	Apply as foliage or basal spray depending on herbicide and season.

INSECTICIDES REGISTERED BY ENVIRONMENTAL PROTECTION AGENCY
For Use in Southern Pine Seed Orchards

Important: Be sure to read labels for dosage and safety precautions. For further information, write to Dr. Larry Abrahamson, Southeastern Area, State and Private Forestry, 1720 Peachtree Road, N.W., Atlanta, Georgia 30309.

Insect Pest	Insecticide	* Example of Registered Labels	Application	Host
Pine Tip Moths	disulfoton	Di-syston® 15 G	Ground	Forest plantings
	carbophenthion	Trithion® 25WP	Not specified	Forest plantings
Nantucket and European	azinphos-methyl	Guthion® 2S;2L; & 50 WP	Not specified	Forest trees
	dimothoate	Cygon® 2E	Ground	Ornamental pines
Nantucket only	trichlorfon	Dylox® 80SP; & LS	High volume ground	Trees
	phorate	Thimet® 10G	Ground	Pine seed orchards (limited to small trees only)
European only	carbophenthion	Trithion® 4E; 8E & 4F	Not specifed	Forest plantings
	zectran	Zectran® 2E; 25WP	Ground	Ornamental pines
	diazinon	Diazinon® AG500; & 50W	Ground	Ornamental pines
	malathion	Malathion® 5E etc.	Ground	Ornamental pines
	methorychlor & kelthane & malathion	505K® Shade Tree Insect Spray	High or low volume ground	Pines
	lindane & kelthane & malathion	202K® Shade Tree Insect Spray	High or low volume ground	Pines
Coneworms (Dioryctria spp.) Seedworms (Laspeyresia spp.)	azinphos-methyl	Guthion® 2S; 2L & 50 WP	High volume ground and low volume ground application	Southern pine seed orchards
Pine Sawflies	methoxychlor & kelthane & malathion	505K® Shade Tree Insect Spray	High or low volume ground	Pines
	lindane & kelthane & malathion	202K® Shade Tree Insect Spray	High or low volume ground	Pines
	methoxychlor	Methoxychlor® 2EC	High or low volume ground	Conifers
	carbaryl	Sevimol® - 4	High volume ground	Ornamental pine
Loblolly (Arkansas)	dimethoate	Cygon® 267; Defend 267	Aerial	Pines
	diazinon	Diazinon® AG 500; AG 4E	Aerial	Pine (seed orchard plantations, forest)

Insect Pest	Insecticide	*Example of Registered Labels	Application	Host
Red-Headed	malathion	Cythion® 57% EL	Low volume ground	Red pine
European	malathion	Cythion® 95% ULV	Aerial	Pines
Red pine	zectran	Zectran® 2E; & 25WP	Ground	Ornamental pines
Seed bugs	No registration specifically for seedbugs, Research is being conducted on finding registered pesticides for these serious insect pests. (Application is also pending to include seed bugs on the Guthion® label for use on Southern seed orchards).			
Stink bugs	trichlorfon	Dylox® 80SP; L.S.	High volume ground	Trees
Scales	azinphos-methyl	Guthion® 2S; 2L; & 50WP	High volume ground	Forest trees
	carbophenthion	Trithion® 4E; 8E; 4F & 25WP	High volume ground	Ornamental pine
	zectran	Zectran® 2E; & 25WP	Ground	Ornamental pine
	diazinon	Diazinon® AG500 etc.	High volume ground	Ornamental pine
	carbaryl	Sevin® 4 Flowable; Sevimol-4, etc.	High volume ground	Ornamental pine
	malathion	Malathion® 5EC etc.	High volume ground	Ornamental trees
	methoxychlor & kelthane & malathion	505K ® Shade Tree Insect Spray	High or low volume ground	Ornamental trees
	lindane & kelthane & malathion	202K® Shade Tree Insect Spray	High or low volume ground	Ornamental trees
	dormant oil	Scalecide® etc.	Ground	Pines
	dormant oil & ethion	6E Oil Spray®	High volume ground	Ornamental pine
Thrips	disulfoton	Di-Syston® 15G	Ground	Forest plantings
	azinphos-methyl	Guthion® 2S; 2L; & 50 WP	High volume ground	Forest trees
	oxydemeton-methyl	Meta-Systox-R®	High or low volume ground	Shade trees
	zectran	Zectran®2E; 25WP	Ground	Ornamental pine
	chlorpyrifos	Dursban® M; & 2E	High volume ground	Ornamental pine
	diazinon	Diazinon® AG500; AG4E etc.	High volume ground	Ornamental pine
	carbaryl	Sevin® 80SP; 50W; 4 Flowable etc.	High volume ground	Ornamental pine
	malathion	Malathion® 5E, etc.	High volume ground	Ornamental trees
Mites	disulfoton	Di-Syston® 15G	Ground	Forest plantings
	azinphos-methyl	Guthion® 2S; 2L; & 50WP	High volume ground	Forest trees
	oxydemeton-methyl	Meta-Systox-R®	High volume ground	Ornamental trees

Insect Pest	Insecticide	*Example of Registered Labels	Application	Host
Mites (cont'd)	demeton	Systox® 2: 6	High volume ground	Ornamental trees
	carbophenthion	Trithion® 4E; 8E4F; & 25WP	High volume ground	Ornamental trees
	diazinon	Diazinon® AG500 etc.	High volume ground	Ornamental pines
	zectran	Zectran® 2E & 25W	Ground	Ornamental pines
	chlorpyrifos	Dursban® M & 2E	High volume ground	Ornamental pines
	malathion	Malathion® 5EC etc.	High volume ground	Ornamental trees
	naled	Dibrom® 8	High volume ground	Forest conifers
	kelthane	Kelthane® 35WP	High volume ground	Ornamental trees
	dormant oil	Scalecide® etc.	Ground	Pines
	methoxychlor & kelthane & malathion	505K® Shade Tree Insect Spray	High or low volume ground	Shade trees
	lindane & kelthane & malathion	202K® Shade Tree Insect Spray	High or low volume ground	Shade trees
White pine weevil	oxydemoton-methyl	Meta-Systox-R®	High or low volume ground	Shade trees
	lindane	Lindane® 20EC	High or low volume ground	Pines
Cone midge	azinphos-methyl	Guthion® 2S; 2L; & 50WP	High volume ground	Forest plantings

*These are examples of labels that have this registered use on them and does not mean that these are the only labeled products that you can use. There may be other products labeled for the same uses. Check the labels of your local available products.

FOREST AND SHADE TREE

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INSECT PESTS OF COMMERCIAL FOREST TREES
(Insects Attacking Pine)

Insect	Host-Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands*
Southern Pine beetle, Dendroctonus frontalis	Pine--All species. Trees killed by girdling by beetles and larvae.	Occasionally epidemic. Mainly active May through October. Beetles and larvae tunnel between bark and wood. Overwinter mainly in larval and pupal stage in bark.	Large numbers of trees attacked in infested areas. Needles of attacked trees yellow-green to red-brown. Pitch tubes on trunk. Main tunnels in inner bark winding, often S-shaped. Beetle is black, 1/8 inch long; end of body rounded, smooth.	Cut and utilize infested trees, burn slabs. Spray felled trees with 1/2% gamma isomer of benzene hexachloride (BHC) in No. 2 fuel oil.* Bark should be dry. Spray to the point of runoff with low-pressure sprayer. On shade trees use 20% lindane at the rate of 2 Tbs. per gallon of No. 2 fuel oil or water. Do not get oil solution on the needles. Spray from the lower limbs to the ground.
Pine engraver beetles, ips species (several species)	Pine--All species. Trees killed by girdling by beetles and larvae.	Very common insects associated with weakened trees. Beetles active throughout the year--most abundant late summer and autumn. Beetles and larvae tunnel between bark and wood. Overwinter as larvae, pupae, and adults in inner bark.	Trees attacked in scattered areas; often associated with lightning injury. Needles of attacked trees yellow-green to red-brown. Pitch tubes along trunk. Main tunnels in inner bark not S-shaped; usually 3-5 tunnels	Good management; healthy trees. Rapid utilization of trees severely affected by fire, disease, or other injury. Spray attacked trees with 1/4% gamma isomer of benzene hexachloride (BHC) in No. 2 fuel

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Insect Pests of Commercial Forest Trees (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands*
			joined to a common chamber. Beetles black or brown, 1/8" to 1/4" long; end of body scooped out, rough.	oil.* Bark should be dry. Spray to the point of run-off with low-pressure sprayer. On shade trees use 20% lindane at the rate of 2 Tbs. per gallon of No. 2 fuel oil or water. Do not get oil solution on the needles. Spray from the lower limbs to the ground.
Black turpentine beetle, Dendroctonus terebrans	Pine-All species. Trees injured at base by adults and larvae. Naval stores trees are highly susceptible during drought.	Commonly develops in fresh stumps. Weakened trees are attacked. May kill large trees if beetles are numerous. Adults and larvae destroy large patches of living tissue between bark and wood.	Large pitch tubes at bases of attacked trees. Foliage turns color and drops when trees are killed. Stout black beetles 1/4" long; end of body rounded, smooth.	Salvage killed trees as rapidly as possible and spray stumps to groundline. Spray freshly attacked trees on all sides from highest point of attack on trunks to ground line. Use 1% gamma isomer of benezene hexachloride (BHC) in No. 2 fuel oil. On shade trees use 20% lindane at the rate of 2 Tbs. per gallon of No. 2 fuel oil or water. Do not get oil solution on the needles. Spray from the lower limbs to the ground.

Insect Pests of Commercial Forest Trees (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands*
Pine sawyers *Monochamus titillator* and several other species.	Pine--All species. Bores large tunnels in wood of dead trees. Destroys value of logs.	Associated with above bark beetles and freshly cut trees. Large long-horned beetles lay eggs in bark. Larvae mine wood surface then tunnel deep into wood.	Presence indicated by rasping sound of larvae feeding. Larvae up to 2" long. Adults stout, 1" long, long antennae, gray, or brown.	Utilize logs or pulpwood promptly. Where prolonged storage is necessary, spray logs and pulpwood with 1/2% gamma isomer of benzene hexachloride (BHC) in No. 2 fuel oil.*
Ambrosia beetles *Platypus* species and *Xyleborus* species.	Pine--All species. Trees show accumulations of white powder in lower trunk region. Wood cut from such trees has "pin-hole damage." Also the wood is degraded due to wood stain.	Attack accompanies or soon follows bark beetle attack. Adults tunnel through bark and deep into wood. The chewed-up wood is pushed to the outside. Fungus grown in the tunnels in the wood is the source of food for adults and larvae.	Brown slender cylindrical beetles 1/8" to 1/4" long. Chewed-up wood pushed out of tunnels is in very fine shreds or dust and not resinous.	Prompt utilization of logs and pulpwood. Spray infested portions of trees with 1/2% gamma isomer of benzene hexachloride (BHC) in No. 2 fuel oil.* On shade trees use 20% lindane at the rate of 2 Tbs. per gallon of No. 2 fuel oil or water. Do not get oil solution on the needles. Spray from the lower limbs to the ground.
Reproduction weevils *Hylobius pales* and *Pachylobius picivorous*	Pine--All species. Weevils strip bark from stem and roots of young trees. Small trees killed.	Weevils feed on tender bark of young trees from buds to roots; March to July. Eggs and larvae in fresh stumps, logs, and pulpwood. New brood of weevils emerges in autumn. Weevils hibernate in litter.	Dark brown to black snout beetles about 1/2" long. Larvae are white, legless, and C-shaped; 1/2" long. Weevils become numerous in stumps after cutting and in trees	Delay planting pine seedlings one full growing season after pine cut. For planting sooner on or adjacent to cutover pine land, dip seedling tops in a water

Insect Pests of Commercial Forest Trees (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands*
			weakened by fire.	emulsion containing 2% aldrin before planting. This chemical may also be sprayed on seedlings after planting.
Red-headed Pine sawfly Neodiprion lecontei	Pine--All species. Defoliation of young trees. Retards growth but seldom kills trees.	Larvae feed in groups on new and old needles. Two or more broods per season. Insect hibernates in cocoon in soil, fly-like adult lays eggs in slits in edges of needles.	Full-grown larvae about 1" long, head red, body cream-colored with rows of black spots. Adult is small and seldom observed.	Apply 3/8 to 3/4 pint of dimethoate (Cygon) (Rebelate) 2.67 pound per gallon emulsifiable concentrate in 2 gallons of water per acre by aircraft, or 1/2 pt. of Diazinon Ag 500 4 pound per gallon emulsifiable concentrate in 2 gallon of water per acre. Malathion 95% (Cythion) may be applied undiluted at the rate 10 fl. oz. per acre by using special nozzles for ULV application. Apply before larvae reaches 1/2 inch in length. Avoid getting on hickory or maple. For shade trees use 3 Tbs. of

Insect Pests of Commercial Forest Trees (Continued)

Insect	Host-Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands*
				Zectran 25W in 1 gallon of water or 2 pounds of Zectran 25W per 100 gallon of water. Carbaryl (Sevin) is cleared for bagworm, elm leaf beetle, mimosa webworm, tent caterpillar and other insects on maple, oak, dogwood, birch and pine.
Other pine sawflies Neodiprion (several species)	Pine--All species. Defoliation of young and mature timber. Retards growth; seldom kills trees.	Larvae feed in groups on new and old needles. Two or more broods per season. Insect hibernates in cocoon in soil. Fly-like adult lays eggs in edges of needles.	Full-grown larvae greenish with dark stripes and head; 3/4" to 1" long. Adult is smaller and seldom observed.	Same as red-headed pine sawfly.
Pine leaf beetle Maecolaspis pini	Pine--All species. Needles red or brown from feeding of beetles. Little or no harm done to tree. Occasionally troublesome.	Adults feed on old needles in May and June. Eggs laid in soil and larvae feed on roots of grasses. Only one generation per year.	Infested trees appear fire scorched. Adult beetle is yellow to brown; 3/16" long.	Control usually not needed. Carbaryl (Sevin) is cleared for bagworm, elm leaf beetle, mimosa webworm, tent caterpillar and other insects on maple, oak, dogwood, birch and pine.

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Insect Pests of Commercial Forest Trees (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodland
Pine Webworm Tetralopha robustella	Pine-All species. Feeds on young needles of seedlings. Growth is retarded.	Caterpillars live within masses of webbing and excreta on terminals of young trees. Several generations per year.	Terminal needles consumed as food. Several brown caterpillars, about 5/8" long, inhabit masses of webbing and brown coarse excreta. Adult moth has wingwpread from 7/8" to 1".	Control is not practical unless infestation is heavy in small areas. Carbaryl (Sevin) is cleared for bagworm, elm leaf beetle, mimosa webworm, tent caterpillar and other insects on maple, oak, dogwood, birch, and pine.
Spittlebug, Saratoga (aphrophora saratogensis)	Feeds on Virginia and Loblolly pine. The nymphs feed on a wide variety of herbs and shrubs. Feeds on pine in the adult stage. The spittle is produced by the nymphs on shrubs and herbs.	Winters in egg stage on pine. Hatch in spring crawl to other host (herb or shrub). Feed and produce spittle. Becomes adults and fly to pine and begin feeding on needle bearing twigs.	Adults are stout-bodied 8 to 11 MM oval or ovalelongate. They are tan to dark reddish-brown with two narrow, oblique, light bands bordered by darker bands on each wing cover. Feeding causes formation of necrotic resin filled pockets in the phloem and xylem tissues. Damaged pines are characterized by the presence of reddish-brown flags of dead foliage.	Weather, parasites predators keep population down, but do not prevent an occasional outbreak. If control is needed use malathion 95% ULV, 10 ozs. per acre by air. Special nozzles are required.

Insect Pests of Commercial Forest Trees (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands*
Pine tip moths Rhyacionia species (several species)	Pine--All species. Loblolly and shortleaf pines most seriously attacked. Buds of small trees killed. Trees stunted and deformed. Infestation is most severe under poor growing conditions.	Small yellow to brown caterpillars mine in buds and transform to small moths in dead shoots. Several generations per year. Moths emerge from March to September. Insect overwinters in killed shoots.	Dead brown shoot tips and buds with a small bubble or blister of gum or pitch at bases of buds. Small trees stunted and deformed. Mining caterpillars are 3/8" to 1/2" long when full grown. Adults are small moths with wing-spread from 3/8" to 3/4".	Plant susceptible pines on good sites only. For small ornamental pines, prune and burn infested tips in very early spring. Apply 3/4 of an oz. of trichlorfon (Dylox) 80% soluble powder in one gallon of water at monthly intervals starting in early spring. Or dimethoate (Cygon) 2 pound to the gallon emulsifiale concentrate at the rate of 4 Tbs. of of the emulsifiable concentrate in 4 gallons of water or 2 pints dimethoate emulsifiable concentrate in 50 gallons of water.

*No. 2 fuel oil will kill grass and shrubs. For park and shade trees around the home, use a spray containing 1/4% to 1/2% gamma isomer of benzene hexachloride (BHC) or lindane in water. See dilution table.

**Carbaryl (Sevin) is cleared for bagworm, elm leaf beetle, mimosa webworm, tent caterpillar and other insects on maple, oak, dogwood, birch, and pine.

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INSECTS ATTACKING PINE CONES AND SEEDS

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control
Pine Cone-worms, Dioryctria species	Larvae destroy buds, shoots, flowers and cones in pine.	Moths lay eggs, and larvae feed on trunks, rust cankers buds, shoots, flowers, or cones. Several generations occur each year.	Mature caterpillars are yellow-brown to purple-brown (5/8" to 1" long). Tunnel extensively in host material, usually push out frass and resin to surface of infested material.	Slash Pine Seed Orchards: Spray tree crown with BHC, 4 lbs. gamma isomer or Guthion, 1.5 lbs. active ingredient per 100 gals. water for cone protection. Hydraulic sprays of either chemical should be applied once during each of the following periods: April 1-15; May 1-15; June 1-15; and July 1-15.
Pine seed-worms, Laspeyresia species	Larvae destroy seed of second-year cones in pine.	Moths lay eggs on cones in spring. Larvae feed on seeds during summer and overwinter in cone axis. One generation occurs each year.	Mature grub-like larvae are white and less than 1/2" long. Feed in seed. No external evidence of infestation in green cones. Cut-open cones contain hollowed seed packed with frass and larval tunnels are present in cone axis during winter.	Slash Pine Seed Orchards: Spray tree crown with Guthion, 1.5 lbs. active ingredient or Sevin, 4.0 lbs. active ingredient per 100 gals. of water. Either chemical should be substituted for BHC during the May 1-15 period in the hydraulic spray schedule for cone-worm control (above).

INSECTS ATTACKING HARDWOODS

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands
Eastern tent caterpillar, Malacosoma americanum	Wild cherry, wild plum, and related species. Defoliation early in growing season.	Eggs hatch when leaves appear in late January or February. Caterpillars live within tent-like webs in the crotches of branches. Caterpillars spin cocoons in protected places in March. Moths emerge in April to lay bands of eggs around twigs. Only one generation per year.	Tent-like silken webs in branch crotches during early spring. Full-grown caterpillars 1 1/2" to 2" long, body dark with a white stripe down the back and covered with long fine light-brown hairs. A row of oval pale blue spots on each side. Moth has dull red-brown wings with two white lines; wingspread 1 1/2".	The webs, containing many caterpillars may be removed mechanically and crushed. If insecticides are needed use carbaryl (Sevin) 80% sprayable. Mix 1 1/4 pounds of the 80% carbaryl in 100 gallons of water or 2 Tbs. per 1 gal. of water, or 2 lbs. of the 50% carboryl (Sevin) W.P. in 100 gal. of water, or 3 Tbs. of carbaryl per 1 gal. of water Also 25% methoxychlorl emulsifiable concentrate may be used. To mix use 5 gal. of the 2 lb. per gal. methoxychlor emulsifiable concentrate to each 15 gallons of water. This mixture is for application by a mist blower. For ground equipment use 2 qts. of the 2 lb. per gallon 25%

Insects Attacking Hardwoods (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands
				methoxychlor emulsifiable concentrate in 100 gal. of water, or 4 Tbs. methoxychlor emulsifiable concentrate in three gal. of water. Zectran 25% wettable powder can be used, mix 1.25 lbs. of the wettable powder in 100 gal. of water, or 3 Tbs. of Zectran wettable powder to 1 gal. of water. Or use 1 to 2 qts. per acre of an aqueaux concentrate of Bacillus thuringiensis. No matter what equipment is used to apply, a minimum of 15 to 20 gal. of water should be used. For small dilutions use 2 to 4 Tbs. for each 3 gal. of water.

Insects Attacking Hardwoods (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodlands-
Forest tent caterpillar, Malacosoma disstria	Oaks, gums, maples and other hard-woods Defoliation early in growing season.	Eggs hatch in March. Caterpillars cause severe defoliation in April. White cocoons spun in protected places. Moths emerge in May to lay bands of eggs around twigs. Only one generation per year.	These caterpillars do not spin a silken tent. Full-grown caterpillars about 1 1/2" long with head and body blue-gray. Row of white spots along back. Moth buff-colored with two dark lines on wings. Wingspread 1" to 1 1/2".	The webs, containing many caterpillars, may be removed and mechanically crushed. 2 lbs. of 50% carbary (Sevin) wettable powder per 100 gal. of water or 3 Tbs. of carbaryl wettable powder in 1 gal. of water, or 1 1/4 lbs. of 80% carbaryl (Sevin) sprayable in 100 gal. of water or 2 Tbs. of 80% carbaryl per gal. of water. Or 2 lbs. of 25% Zectran wettable powder per 100 gals. of water, or 3 Tbs. of 25% wettable powder per 1 gal. of water. Or 1 to 2 qts. of the aqueous concentrate of Bacillus thuringiensis in a minimum of 15 gal. of water per acre. For small amounts use 2-4 Tbs. for each 3 gal. of water.

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Insects Attacking Hardwoods (Continued)

Insect	Host-Damage	Habits and Life History	Recognizing Insect and Injury	Control--Woodland
Fall webworm, Hyphantria cunea	Many hardwood trees are host. Most frequent on hickory, pecan, sweetgum, and persimmon. Defoliation.	White moths, with 1 1/4" wingspread, lay masses of white eggs on undersides of leaves. There are a number of generations from April to October. Masses of caterpillars live within silken webs on tips of branches. Cocoons in litter or soil	Webs on ends of defoliated branches. Hairy yellow to gray caterpillars in large numbers within webs. Caterpillars about 1 1/4" long when full grown. Adult is a white moth with wingspread about 1 1/4".	2 lbs. of 50% carbaryl (Sevin) WP per 100 gals. of water or 3 Tbs. carbaryl per gal. of water for smaller quantities. Or 1 1/4 lbs. of 80% sprayable carbaryl (Sevin) per 100 gals. of water. For small amts. mix 2 Tbs. of carbaryl per 1 gal. of water.
Ambrosia beetles Platypus species AND Xyleborus species	Any species of hardwood trees. Trees show accumulations of white powder in lower trunk region. Wood cut from such trees has "pin hole damage."	Beetles attack weakened trees. Adults tunnel through bark and deep into wood. The chewed up wood is pushed to the outside. Fungus grown in the tunnels in the wood is the source of food for adults and larvae.	Brown slender cylindrical beetles 1/8" to 1/4" long. Chew-up wood pushed out of tunnels is in very fine shreds.	Prompt utilization of infested trees and logs. Spray infested portions of trees with 1/2% gamma isomer of benzene hexachloride (BHC) in water. For use on shade trees, mix 3 pts. of 20% lindane, 1.65 lb. to the gal., emulsifiable concentrate in 100 galls. of water, or 2 Tbs. of 1.65 to the gal. lindane emulsifiable concentrate to 1 gal. of water.

BHC AND LINDANE SPRAYS:

To make a spray containing approximately 1/4% gamma isomer of Benzene hexachloride (BHC) or lindane, mix one of the following in 50 gallons of water or No. 2 fuel oil; to make a 1/2% spray, double the amount and for a 1% spray use 4 times as much.

1. 1 gallon of 11%-12% BHC emulsifiable concentrate (containing 1 lb. of gamma BHC per gallon).
2. 8 pounds of 12% BHC wettable powder.
3. 5 pints of 20% lindane emulsifiable concentrate.
4. 4 pounds of 25% lindane wettable powder.

NOTE: Wettable powder formulations may be more readily available than emulsifiable concentrates, but are less desirable when mixed in fuel oil because they tend to form a sludge in the spray. Wettable powders are satisfactory in water sprays applied by sprayers with adequate agitation.

INSECTS ATTACKING SHADE TREES

Insect	Host-damage	Habits and Life History	Recognizing Insect & Injury	Control--shade Trees
Carpenterworm, Prionoxystus robiniae	Oaks ash, elms, and other hard-woods.	Moths lay eggs on trunk mostly during May and June. The larvae bore through the bark and tunnel in the wood for 1 to 2 years before pupating and producing adults.	Young larvae are cherry red but later fade to yellowish white (1/4"-3"). Infested trees can be recognized by sap-stained bark, frass, and openings in the bark.	Unthrifty trees are especially susceptible to attack from this pest. To prevent attack try to keep shade trees thrifty and growing. This can be done by fertilizing in the spring and watering during periods of prolonged draught. Also prevent wounds. Or if the tree is wounded apply a wound treatment. Larvae in small trees can be killed by probing their tunnels with a wire.

INSECTS ATTACKING SHRUBBERY TREES

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control
Elm Leaf Beetle *Pynhalta luteola*	Feeding itself generally will not kill an elm tree. Severe feeding will weaken a tree making it more susceptible to other insects and diseases. This pest infest Chinease elms mostly.	About mid-May, overwintering beetles deposit their eggs on the underside of leaves. Eggs hatch in about a week and feed on underside of the leaves for the next 2 to 3 weeks. Only the veins and upper surface are left, giving leaves a "skeletonized" appearance. Those heavily infested turn brown as if scorched by fire. Defoliated trees may grow new leaves the same season, but at times this second leafing will be destroyed by the second generation beetles. Full-grown larvae crawl down the tree and pupate in bark crevices or at the base of the tree.	The adult beetle is somewhat oval and about 1/4" long. When newly hatched from the pupa stage, it is light yellow with a black stripe along each outer margin of the back. As the beetle ages, the yellow color dulls to an olive green and the black stripes become less distinct. Eggs are bright yellow and spindle shaped and are laid in clusters of 5 to 25 on underside of leaves.	Spraying of infested trees should be timed to kill the young first generation larvae. Make first application in late May or early June and second application in late July or early August. Spray endosulfan, (Thiodan) 2 lbs. per gal. EC at 2 qts. in 100 gals. water or at 4 tsp. in 1 gal. of water. OR spray carbaryl (Sevin) 50% WP at 2 lbs. in 100 gals. water or 2 tsp. in 1 gal. of water. Systemics also give control. Use dimethoate (Cygon) EC at the rate of 2 tsp. per gal. of water.

Insects Attacking Shrubbery Trees (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control
Mimosa Webworm Homadula anisocentra	Attacks both the mimosa and honeylocust tree. Larvae web the foliage together and skeletonize the leaflets causing infested trees to turn brown as if scorched by fire.	The mature larva pupates on the ground on tree trunks, in old webbing left by feeding worms and in other sheltered places. The insect's two generations often overlap and all stages can be found during summer. The second generation overwinters in the pupal stage.	The mimosa webworm is a small silvery-gray moth which has wings stippled with black dots. Adults lay eggs on foliage and in old webbing. The eggs are tiny, oval and at first pearly-white and turn pink as hatching time nears. The full-grown larva is about an inch long and grayish-brown in color with 5 white stripes running lengthwise down the body. It has a dark head and the body is sometimes tinged with pink.	Control with sanitation practices and spraying. Since many of the webworm pupae overwinter in debris on the ground, leaves should be raked from under infested trees in the fall and composted or burned. Homeowner. Spray 50% carbaryl (Sevin) WP at 2 lb. in 100 gals. water or 2 T. in 1 gal. water. OR 60% toxaphene EC at 3 pts. in 100 gals. water or 3 t. in 1 gal. water. Apply one of these sprays in early June and again in early August. Repeat as needed for enough pressure to penetrate webs and wet the foliage. 57% malathion EC or 25% diazinon EC at 2 teaspoons per gal. of water is also effective.

Insects Attacking Shrubbery Trees (Continued)

Insect	Host--Damage	Habits and Life History	Recognizing Insect and Injury	Control
Mimosa Webworm				Granular Insecticide- 2% disulfoton (Di-Syston) Sprinkle around base of plant. Mix into soil and water thoroughly. Commercial. Spray Di-Syston 6 lb. per gal. EC at 2 qts. in 100 gals. water or 4 teaspoons per gal. water. OR 25% Thrithion WP at 2 qts. in 100 gal. water or 4 teaspoons in 1 gal. water. OR Ethion 4 lb. per gal. EC at 1 qt. in 100 gals. water or 2 teaspoons in 1 gal. water. OR 18.6% dieldrin EC at 1 qt. in 100 gals. water or 2 teaspoons in 1 gal. water. These are highly poisonous and should be used only as directed.

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